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MANUFACTURING METHOD OF LIGHT METAL PRODUCT
[Keikinzoku seihin no seizo hoho]

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Claims /2*

1. A molding method of light metal product characterized by the following facts: a casting melt mainly made of light metal material is formed in a primary mold, so that a preparatory molding smaller by a round than the final product is cast; the preparatory molding is accommodated in a secondary mold having the shape of the target product and sealed except the moving region of the pressing means to be explained later; while the temperature is set as high as possible as long as the mobility is not hampered, the preparatory molding has a portion or the entirety of the pads preformed on the preparatory molding so as to ensure a prescribed forging ratio pressed by one or several pressing means annexed to said secondary mold; as a result, said pads are shifted to the target product side, and the target product in the prescribed shape is formed.

2. A molding method of light metal product characterized by the following facts: a casting melt mainly made of light metal material is formed in a primary mold, so that a preparatory molding smaller by a round than the final product is cast; the preparatory molding is accommodated in a secondary mold having the shape of the target product and sealed except the moving region of the pressing means to be explained later; at a temperature in the range where the liquid phase and solid phase coexist in the metal structure of the preparatory molding, the preparatory molding has a portion or the entirety of the pads preformed on the preparatory molding so as to ensure a prescribed forging ratio pressed by one or several pressing means annexed to said secondary mold; as a result, said pads are shifted to the target product side, and the target product in the prescribed shape is formed.

3. The molding method of light metal product described in Claim 2 characterized by the fact that a recession is formed on the preparatory molding, and, while an inset mold having an outer shape same or similar to the shape of the recession of the target product is filled in the recession such that it can be

* [Numbers in the margin indicate pagination of the original document.]

pulled off from the final molding. In the secondary mold, the pads, which are preset on the preparatory molding in the secondary mold, are pressed by a pressing means.

4. The molding method of light metal product described in any of Claims 1-3 characterized by the fact that the pressing means has a shape of the hole and/or recession to be formed on the target product.

5. A molding method of light metal product characterized by the following facts: a casting melt mainly made of light metal material is formed in a casting mold to have a moldability, so that a preparatory molding in a shape similar to that of the target product, having a recession and containing pads for guaranteeing the prescribed forging ratio; in said recession formed on the preparatory molding, an inset mold having an outer shape same or similar to the shape of the recession of the target product is set such that it can be pulled off from the final molding; in this state, at a temperature in the range where the liquid phase and the solid phase coexist, forging processing is performed using a forging mold; then, said inset mold is pulled out, and, as needed, post processing is performed to form the target product.

6. The molding method of light metal product described in Claim 5 characterized by the fact that the recession formed on the preparatory molding accommodated in the stationary-side forging die includes a recession that extends in the direction crossing the movement direction of the movable-side forging die, and the structure is such that the inset mold can be inserted via the stationary-side forging die into said recession.

Detailed explanation of the invention

[0001]

Industrial application field

The present invention pertains to a manufacturing method, especially a molding method, of light metal products made of aluminum, magnesium, titanium, and other light metals.

[0002]

Prior art

Taking aluminum product as a typical example of the light metal product, as the method for forming the product with complicated concave/convex surfaces, holes, etc., the casting method may be adopted. In this method, the volume shrinks in solidification, the solidification rate of the thicker portion and that of the thinner portion become different from each other, and air is entrained easily into the melt when melt is fed to the casting mold. Due to these factors, shrink pockets, pinholes, cracks, and other defects may take place easily, and there exists a certain limit in forming uniform perfect structure. Also, with regard to the structure of the cast products, usually, in order to improve the moldability that used to be rough, silicon compound or the like is blended, so that in the alumite treatment, because the oxide coating film of alumite is not formed in the non-metal portions, such portions are prone to corrosion, and the desired product with good appearance cannot be obtained. This is undesired.

[0003]

The forged products are free of said disadvantage. However, for manifolds and various types of valves, which require holes in plural directions in the final product shape, when a forging mold that can make up/down reciprocal movement is used, although it is possible to form holes in the reciprocal movement direction, in order to form holes extending in the direction crossing the reciprocal movement direction, after the outer shape is formed by forging, it is necessary to form the holes by means of cutting processing. As a result, the man-hour becomes larger, and the manufacturing cost becomes higher. This is a disadvantage.

[0004]

In order to avoid the disadvantages of the two schemes, people have proposed a manufacturing method that can manufacture products with less disadvantages by means of a combination of the advantages of casting and forging. In this method, first of all, a cast molding is cast by means of a sand mold. This cast molding is formed a little larger than the final product shape so as to guarantee the forging ratio (forging molding ratio). A forging mold with the final product shape is prepared and pressing is performed in the forging mold, so that the pads are removed as burrs, and the final product is formed (Japanese Kokoku Patent Application No. Sho 32[1957]-8161).

[0005]

Usually, the cast products made of aluminum alloy and other light metal materials have melt wrinkles, cast pockets, surface cracks, and other characteristic defects. Consequently, when the cast structure is modified in addition to the forging processing, depending on the shape of the product, plastic deformation mainly takes place in the linear direction, so that modification can hardly be performed without deformation of at least 15-20 vol%. However, according to experiments performed by the present inventor, for the cast products formed by sand mold, because the solidification time is long, the metal crystal structure is significantly developed, so that the structure becomes too rough, and, even when forging is performed for plastic deformation by forging with the possible forging ratio, it is still difficult to perform modification.

[0006]

In addition, even when a cast product formed by mold is used as the preparatory molding, it is difficult to solve the aforementioned problems. By improving forging of the cast structure, it is necessary to perform plastic processing at a forging ratio (forging molding ratio) over a prescribed level. /3 According to the aforementioned method, when a cast molding prepared to be larger by a round than the final product shape is molded by pressing using a forging mold, the pads become burrs that squeeze out from the joint portion between the upper/lower dies. As the forging product is pressed, first of all, burrs are removed, and, then the burrs are cut off, and the residual surface is polished to form the final product.

[0007]

Said burrs are the portion the receives the largest plastic deformation under the high pressure of the forging mold, and the rough forging structure is made finer and shift in laminar configuration takes place. Consequently, no matter how much the surface formed after cutting off of the burrs is polished, the metal structure is different from the other cast structure. As a result, layers formed by superposing numerous fine fiber-like strings, leading to poor appearance of the product. This is undesired. Consequently, this method can hardly be used for the products that put emphasis on the appearance. Because said layers are generated due to difference in metal structures, it is difficult to make it insignificant even in alumite processing.

[0008]

On the surface obtained by removal of burrs by shear processing, fine cracks are generated, so that stress is concentrated on the cracks. As a result, cracks are developed, and accidents may take place. In

addition, in order to ensure that the shape becomes planar shape after removal of the burrs, the forging mold should be prepared such that the burrs do not protrude on the portion as a curved surface. While it is difficult to prepared the mold, the product that requires good appearance, that is, product that must have the dividing plane of the mold at the curved surface portion, cannot be formed using this method. In addition, as explained above, for the forging mold, although holes parallel to the up/down movement direction can be formed, when the target product should have holes in the horizontal direction, other methods, such as cutting processing, etc., that require a lot of man-hour, have to be adopted. As a result, it is difficult to cut the manufacturing cost.

[0009]

Purpose of the invention

A purpose of the present invention is to disclose a method for molding light metal product, which has a fine metal structure, a uniform good appearance, and a complicated shape with a lot of protrusions and recessions, at a low cost.

[0010]

Constitution of the invention

The first item of the present invention provides a molding method of light metal product characterized by the following facts: a casting melt mainly made of light metal material is formed in a primary mold, so that a preparatory molding smaller by a round than the final product is cast; the preparatory molding is accommodated in a secondary mold having the shape of the target product and sealed except the moving region of the pressing means to be explained later; while the temperature is set as high as possible as long as the mobility is not hampered, the preparatory molding has a portion or the

entirety of the pads preformed on the preparatory molding so as to ensure a prescribed forging ratio pressed by one or several pressing means annexed to said secondary mold; as a result, said pads are shifted to the target product side, and the target product in the prescribed shape is formed.

[0011]

As explained above, the preparatory molding is fetched from the casting mold, and, while at a sufficiently high temperature, while the protection is maintained, it is accommodated in a secondary mold, or, by means of the remaining heat, the preparatory molding is accommodated in the secondary mold while the moldability of the preparatory molding is not hampered. Or, it is heated in the secondary mold, and the temperature is raised to the prescribed temperature, or said heating means are used together to perform molding in the secondary mold. Said temperature depends on the type of the casting metal material. It is preferred that the temperature be in the range of temperature where the liquid phase and solid phase coexist while solidification is performed, and the pads in the secondary mold are pressed. It is most preferred that the operation be performed in the temperature range where the proportion of the liquid phase is about 20-30%. However, molding in said solid/liquid coexisting state is not a necessity for the method of the invention described in said first item. For example, when the recession to be formed has a simple shallow concave shape, there is no need to have the liquid phase present. With regard to the schemes for dividing the secondary mold, one may adopt any of the upper/lower dividing scheme, left/right dividing scheme, upper/lower lateral dividing scheme, etc.

[0012]

The second item of the present invention pertains to the molding method of light metal product described in said second item characterized by the fact that a recession is formed on the preparatory

molding, and, while an inset mold having an outer shape same or similar to the shape of the recession of the target product is filled in the recession such that it can be pulled off from the final molding, in the secondary mold, the pads, which are preset on the preparatory molding in the secondary mold, are pressed by a pressing means.

[0013]

Said inset mold is usually inserted and set in the recession of the preparatory molding through the opening set on the secondary mold. While the opening as the guide path of the inset mold is closed by a portion of the inset mold, it is inserted and set in the preparatory molding, and a pressing means is adopted to press the pads. After molding, it is pulled off from the molding by means of a mold pulling device equipped with a hydraulic cylinder or the like. Consequently, it is preferred that a pulling slope be formed for the inset mold. With regard to the shape of the recession of the target product, when the recession has a shape such that if the inset mold is manufactured in the shape of the final product, it would be impossible to pull it off after molding, an inset mold that can be pulled off and has an outer shape similar to the final product shape is used. After pull off, simple cutting processing or the like is performed to form the target product.

[0014]

According to the method described in said first or second item, the pressing means for pressing the pads has a shape of the hole and/or recession to be formed on the target product. As a result, movement of the pads is realized such that the prescribed forging ratio can be met, and, at the same time, lateral holes and other recessions to be set on the product are formed. This is also included in the range of the present invention. According to the method of the present invention as described in said item 1 and 2, by

means of preparatory molding using casting method, a shape similar to that of the target product can be obtained. Consequently, when the pads are partially pressed for molding, it is possible to prevent entrainment of gases, oxide film and foreign objects, fold-over phenomenon that used to take place easily when the metal for molding passes through the narrow portion, and formation of joint /4
seams between different metal structures. Because the product is pressed and molded in a sealed mold, the shape precision is high. In addition, because molding is performed while the liquid phase is mixed in, it is possible to form the lateral holes, etc., that used to be impossible to be formed in the conventional forging processing.

[0015]

The third item of the present invention provides a molding method of light metal product characterized by the following facts: a casting melt mainly made of light metal material is formed in a casting mold to have a moldability, so that a preparatory molding in a shape similar to that of the target product, having a recession and containing pads for guaranteeing the prescribed forging ratio; in said recession formed on the preparatory molding, an inset mold having an outer shape same or similar to the shape of the recession of the target product is set such that it can be pulled off from the final molding; in this state, at a temperature in the range where the liquid phase and the solid phase coexist, forging processing is performed using a forging mold; then, said inset mold is pulled out, and, as needed, post processing is performed to form the target product.

[0016]

According to the invention defined in said third item, the recession formed on the preparatory molding accommodated in the stationary-side forging die includes a recession that extends in the

direction crossing the movement direction of the movable-side forging die, and the structure is such that the inset mold can be inserted via the stationary-side forging die into said recession. As the method for casting the preparatory molding in said first through third items, one may adopt any of the gravity casting method, low pressure casting method, centrifugal casting method, etc. According to said invention of said third item, recessions, lateral holes, etc. are formed beforehand in the preparatory molding prepared by casting, and the inset mold is inserted in it for molding. As a result, the preparatory molding that has been preheated to semi-solidified state is filled uniformly around the inset mold, so that no force acts to lead to deformation of the inset mold, and, it is possible to form the lateral holes, which used to be unable to form in the conventional forging processing, at the same time of forging. In the following, an explanation will be given in more detail regarding application examples.

[0017]

Application Example 1

Using a conventional method, casting melt made of aluminum alloy was made to flow into a gravity casting mold (not shown in the figure) as the primary mold to form preparatory molding (1) shown in Figure 1. On preparatory molding (1), pads (1a), (1a) are formed with a portion protruding upward on the portion corresponding to holes (3), (3) to be formed in final product (2) and the portions above them, with sufficient quantity in consideration of the forging ratio. At the time when a sufficient moldability is realized, said preparatory molding (1) is fetched from the opened casing mold, and, as needed, it is heated by a heating oven to a temperature in the temperature range (say, 550-600°C) where solid and liquid of the aluminum cast alloy coexist. It is carried on lower die (5) of the secondary mold kept at the prescribed temperature beforehand, and upper die (6) is closed. The shape of the preparatory molding is

formed smaller by a round than the shape of the interior of the secondary mold having the shape of the final product in consideration of the forging ratio.

[0018]

On upper die (6) of the secondary mold, openings (6a), (6b) are formed to open the top portion of said pads (1a), (1b) [sic; (1a)]. The lower ends of press rods (7a), (7b) are set as pressing means on openings (6a), (6b) in a free up/down reciprocal movable way by means of a hydraulic cylinder or the like. The outer shapes of press rods (7a), (7b) are formed the same as the shapes of holes (3), (3) of final product (2). Right after upper die (6) is closed, press rods (7a), (7b) are lowered to enter until the lower dead point, and pads (1a), (1a) are pressed into the peripheral cast structure. Consequently, the cast structure is pressed and driven to shift, and preparatory molding (1) has the shape changed so that the gap between the secondary mold and the preparatory molding (1) is buried, and the inner wall of the secondary mold is forcibly pressed. As a result, molding comes to an end. Then, the press rods are retreated, and the secondary mold is opened to have the molding taken out. As needed, the peripheral edge of hole (3) is trimmed, and final product (2) is obtained.

[0019]

Effect

Using the aforementioned method, in the secondary molding operation, the cast structure in the semi-solidified state is pressed by the pressing means to shift slowly, so that no air is entrained. Also, as the cast structure has crystal portions nearly in the same size densely dispersed in the melt metal. Consequently, it is possible to obtain a perfect structure with homogeneous density. In addition, because (6) is sealed, no burr takes place at dividing plane (8) of the upper/lower dies. That is, only a single line

is visible, so that there is no need to adopt the burr removing operation, and the appearance is not degraded.

[0020]

Application Example 2

Just as in Application Example 1, preparatory molding (10) shown in Figure 3 is cast from an aluminum cast alloy using a gravity casting mold. Said preparatory molding (10) is composed of principal molding portion (11) having a shape similar to that of the target product, and feeding head portion (12) for forming perfect principal molding portion (11). On principal molding portion (11), lateral hole (13) with a diameter larger than that of lateral hole (21) is formed at the site corresponding to the formation position of said lateral hole (21) formed on final product (20) shown in Figure 5. Said preparatory molding (10) is preheated at a temperature at which the solid phase and liquid phase coexist, and it is driven to move in the lateral direction so that it is accommodated in a secondary mold consisting of left-die (15) that seals the mold, and right-die (16) that is fixed, and the top portion of feeding head portion (12) is removed and the mold is sealed. The secondary mold is also kept at the temperature just as in Application Example 1.

[0021]

On the right-die, at the position corresponding to lateral hole (13) of the preparatory molding, through hole (17) is formed superposed in lateral hole (13). In said through hole (17), inset mold (18) having an outer shape identical to the shape of lateral hole (21) of final product (20) is set such that it can enter/leave the interior of the secondary mold by means of cylinder rod (19a) of hydraulic cylinder (19). Said inset mold (18) is accommodated in lateral hole (13), and it is set in the secondary mold. From

the upper opening of top portion (12a) of feeding head portion (12), pressing rod (20) [sic; (19)] is lowered, and feeding head portion (12) is pressed. Said preparatory molding (10) is in the semi-solidified state, and the pressing force of final product (20) is not so large. Usually, the purpose can be realized under a pressure of 2000-4000 kg/cm^2. By means of said pressing rod (20) [sic; (19)], only /5
the feeding head portion is pressed. After end of the partial pressing molding, the pressing rod is raised, and, at the same time, the inset mold is detached from the molding. The left/right dies are opened, the molding is taken out, the residue of the feeding head portion is separated at boundary portion (22) with final product (20). As a result, final product (20) with lateral hole (21) as shown in Figure 5 is obtained.

[0022]

Effect

With the aforementioned method, for the target product, the same advantages as those in the case of Application Example 1 can be realized. In addition, by means of cutting processing, lateral hole (21) can be formed at the same time. Also, the interior of the lateral hole can be formed much smoother that that obtained by cutting processing.

[0023]

Application Example 3

Figures 6 and 7 are diagrams illustrating the high-efficiency manufacturing method with the same method as that of Application Example 2. Here, preparatory molding (30) made of an aluminum alloy cast formed using the gravity mold casting method has principal molding portion (31) having a shape similar to the shape of the target product, feeding head portion (33) as the pads, and latching portion (32) having hole (32a) for hanging on positioning pin (37) set in stationary die (35) as one of the dies of the

secondary mold. In principal molding portion (31), lateral hole (34) that is a round larger than the lateral hole to be formed on the final target product is formed on the side surface. The other die of the secondary mold is composed of stationary die (35) fixed on stationary platen (37) set on the die holder, and movable die (36), which is moved from the side to stationary die (35) to close the mold.

[0024]

Said stationary die (35) has pin (37), which is inserted in hole (32a) on preparatory molding (31), and defines the preparatory molding at the prescribed position, inset mold (38) inserted in lateral hole (34), and hydraulic cylinder (40), which sets said inset mold in/out through opening portion (39) set at the position corresponding to lateral hole (34) of stationary die (35). In addition, in stationary die (35), guide opening (35a) is set at the portion facing feeding head portion (33). In this guide opening, pressing mold (41) is accommodated as a pressing means that makes reciprocal movement. Piston rod (42) that drives pressing mold (41) through cylinder (43) going through the lower portion of stationary platen (37), and it is connected to the piston of the hydraulic cylinder not shown in the figure. Here, (36a) represents an relief hole of positioning pin (37) set through movable die (36).

[0025]

Said secondary mold is used, and preparatory molding (31) is sufficiently heated to a temperature in the range where the liquid phase and the solid phase coexist, and then it is fixed by means of positioning pin (37) by means of an appropriate transporting means. Then, inset mold (38) is driven to move so that it is inserted into lateral hole (34). Then, pressing mold (41) is driven forward until the pressing start position, and, at the same time, movable die (36) is driven to move to close the secondary mold. Until this stage, the secondary mold is preheated or kept at the temperature so that it is in the temperature

range where partial pressing molding can be performed. In this state, pressing mold (41) presses feeding head portion (33) to perform secondary molding. Then, pressing mold (41) is retreated, inset mold (38) is detached, movable die (36) is driven to move, and the molding is taken out.

[0026]

Effect

As explained above, the secondary mold is used, and it is easy to perform automated operation in preheating or maintenance of temperature and transportation of the preparatory molding, as well as mounting on the secondary mold and fetching from the mold, and a product with a lot of recessions and protrusions including lateral hole (34) and other recessions can be manufactured easily and at a high efficiency by means of pressing and cutting of feeding head portion (33) and latching portion (32). As a result, a complicated product can be manufactured at a low cost.

[0027]

Application Example 4

Figures 8-9 are diagrams illustrating Application Example 4 of the method of the present invention. Said preparatory molding (50) is an aluminum alloy cast product formed by gravity cast mold just as in said Application Examples 1-3. On said preparatory molding (50), large/small lateral holes (51), (52) larger than lateral holes (71), (72) to be formed on final target product (70) as shown in Figure 9 are formed, respectively. On the other hand, the secondary mold is composed of forging lower die (61) fixed on the die holder, and forging upper die (62) that moves up/down. On said lower die (61), inset molds (63), (64) having the shapes of lateral holes (71), (72) of final target product (70) are set facing openings (65), (66) formed on the side wall surface of said lower die (61).

[0028]

On the other hand, on upper die (62), protruding portion (69) is set for forming vertical hole (73) that extends from near the central portion of the upper surface downward in final target product (70). In said forging mold, preparatory molding (50) is preheated or at a temperature at which the liquid phase and the solid phase coexist without finishing of solidification, as it is taken out from the forging mold, and the upper die is set on lower die (61). Of course, upper/lower dies (62), (61) are well preheated at a temperature in the range where a mold releasing agent can be coated. Inset molds (63), (64) are inserted and fixed at the prescribed positions in lateral holes (51), (52), and then upper die (62) is lowered slowly to perform pressing molding of the preparatory molding. After end of molding, while upper die (62) is driven to move upward, inset molds (63), (64) are retreated, and the target molding is taken out from the mold.

[0029]

Effect

According to the aforementioned method, inset molds (63), (64) are accommodated in preset lateral holes (51), (52), and, when pressure is applied, pads (50a) and other pads exhausted by protruding portion (69) of the upper die homogeneously fill the periphery of the inset molds. As a result, there is no deformation under pressure, and, even when lateral hole (72) has a slender shape, it still can be pulled out easily after molding. Especially, when the inset molds interfere with the movement region of protruding portion (69), and deformation may take place (for example, when the lateral holes and vertical holes on the target product cross each other and connected to each other), as shown in Figure 9, vertical hole (73), and lateral holes (71), (72) are set until the state right before connection. As needed,

cutting processing is performed to have them connected. In this case, compared with the case of opening of lateral holes in the forging product in the prior art, the processing operation becomes much simpler.

[0030]

According to the method in said Application Example 4, it is possible to form fine and deep lateral /6 holes easily, and, depending on the forging molding operation, the cast structure can be well improved, and high quality products can be formed at a lower cost. Here, the pressure of the preparatory molding is about 2000-4000 kg/cm^2 under hydraulic pressure, and the energy needed for molding is much smaller than that in the conventional forging operation. Because molding is performed by pressure instead of impact force, noise is lower.

Brief description of the figures

Figure 1 is a diagram illustrating the main portion of Application Example 1 of the method of the present invention.

Figure 2 is a diagram illustrating the outer shape of the target product formed using the method in Application Example 1.

Figure 3 is a diagram illustrating the outer shape of the preparatory molding used in Application Example 2.

Figure 4 is a diagram illustrating the molding step of operation using the secondary mold in Application Example 2 of the method of the present invention.

Figure 5 is a diagram illustrating the outer shape of the target product in Application Example 2 of the method of the present invention.

Figure 6 is a diagram illustrating the state of setting of the preparatory molding in the stationary die in Application Example 3 of the method of the present invention.

Figure 7 is a diagram illustrating the constitution of the secondary mold used in Application Example 3 of the method of the present invention.

Figure 8 is a diagram illustrating the main portion of Application Example 4 of the method of the present invention.

Figure 9 is a cross-sectional view of Application Example 4 illustrating the constitution of the target product in the method of the present invention.

Explanation of symbols

1, 10, 30, 50	Preparatory molding
2, 20, 70	Target product
1a, 50a	Pads
5, 6, 15, 16, 35, 36	Secondary mold
12, 33	Feeding head portion
7a, 7b	Pressing rod
18, 34, 63, 64	Inset mold
20	Pressing rod
37	Positioning pin
41	Pressing mold
71, 72	Lateral hole

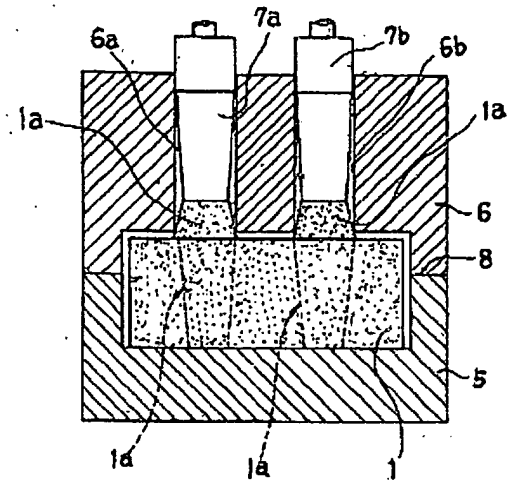

Figure 1

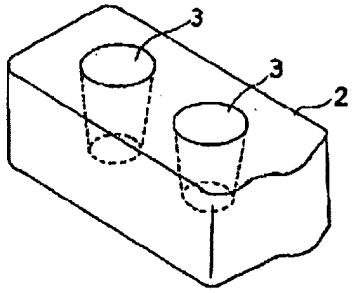

Figure 2

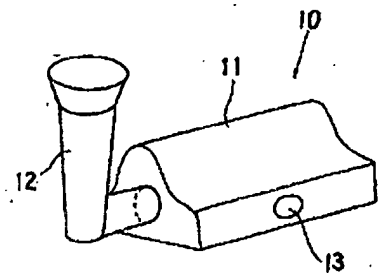

Figure 3

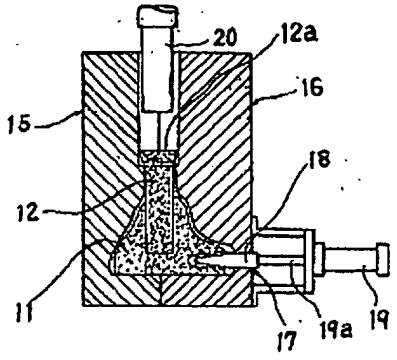

Figure 4

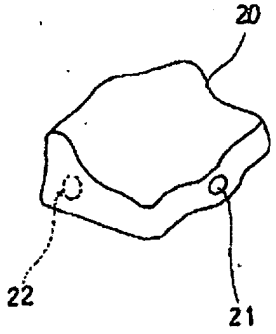

Figure 5

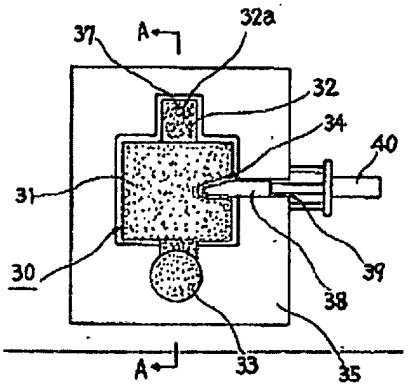

Figure 6

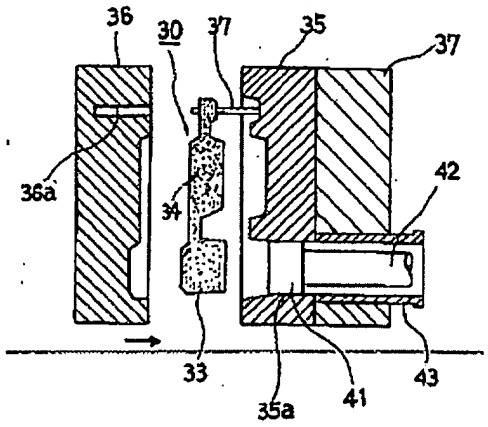

Figure 7

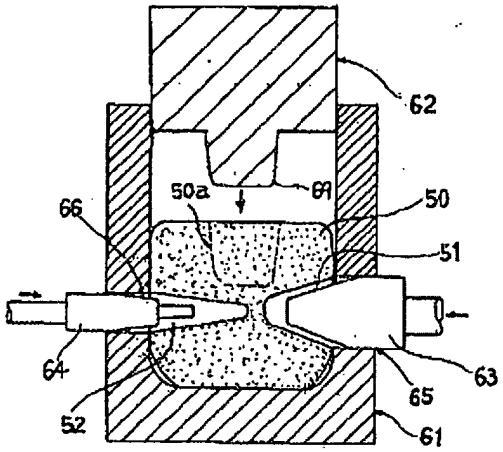

Figure 8

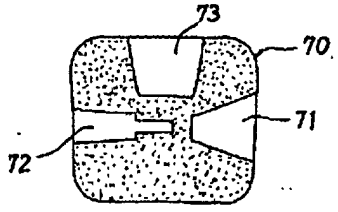

Figure 9